Lecture 11 – Classes & Objects continued …

https://cw.fel.cvut.cz/wiki/courses/be5b33prg/start

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RECAP: OOP PERSPECTIVE

OOP is about changing the perspective

- Syntax for a function call: **function_name(variable)**
  function is the one who executes on the variable
- Syntax in OOP: **object_name.function_name()**
  object is the one who executes its method on given data / attribute

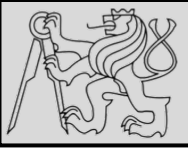
source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_I.html

RECAP: CLASS vs. TUPLE

```
1  class Point:
2      """ Create a new Point, at coordinates x, y """
3
4      def __init__(self, x=0, y=0):
5          """ Create a new point at x, y """
6          self.x = x
7          self.y = y
8
9      def distance_from_origin(self):
10         """ Compute my distance from the origin """
11         return ((self.x ** 2) + (self.y ** 2)) ** 0.5
```

- Advantage of using a class (*e.g. Point*) rather than a tuple is that **class methods are sensible operations** for points, but may not be appropriate for other tuples (*e.g. calculate the distance from the origin*)
- Class allows to **group together sensible operations** as well as data to apply the methods on
- Each instance of the class has its **own state**
- Method **behaves like a function** but it is invoked on a specific instance

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_I.html



RECAP: EXAMPLE – INSTANCE METHODS


```
class Inst:

    def __init__(self, name):
        self.name = name

    def introduce(self):
        print("Hello, I am %s, and my name is " %(self, self.name))
```

```
myinst = Inst("Test Instance")
otherinst = Inst("An other instance")
myinst.introduce()
# outputs: Hello, I am <Inst object at x>, and my name is Test Instance
otherinst.introduce()
# outputs: Hello, I am <Inst object at y>, and my name is An other instance
```

SOURCE https://stackoverflow.com/questions/17134653/difference-between-class-and-instance-methods

```
class Cls:

    @classmethod
    def introduce(cls):
        print("Hello, I am %s!" %cls)
```

```
Cls.introduce() # same as Cls.introduce(Cls)
# outputs: Hello, I am <class 'Cls'>
```

Notice that again `Cls` is passed hiddenly, so we could also say `Cls.introduce(Inst)` and get output `"Hello, I am <class 'Inst'>`. This is particularly useful when we're inheriting a class from `Cls`:

```
class SubCls(Cls):
    pass

SubCls.introduce()
# outputs: Hello, I am <class 'SubCls'>
```

SOURCE https://stackoverflow.com/questions/17134653/difference-between-class-and-instance-methods

```
1  class Rectangle:
2      """ A class to manufacture rectangle objects """
3
4      def __init__(self, posn, w, h):
5          """ Initialize rectangle at posn, with width w, height h """
6          self.corner = posn
7          self.width = w
8          self.height = h
9
10     def __str__(self):
11         return  "({0}, {1}, {2})"
12                     .format(self.corner, self.width, self.height)
13
```

- EXAMPLE: assume a rectangle that is oriented either vertically or horizontally, never at an angle;
  specify the upper-left corner of the rectangle, and the size

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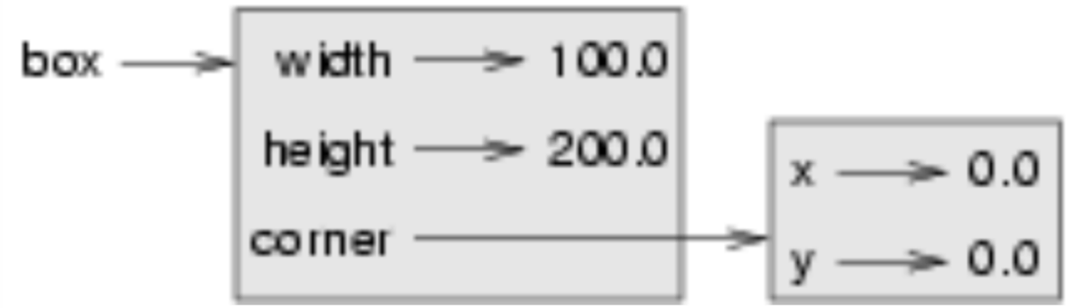
```
1   class Rectangle:
2       """ A class to manufacture rectangle objects """
3
4       def __init__(self, posn, w, h):
5           """ Initialize rectangle at posn, with width w, height h """
6           self.corner = posn
7           self.width = w
8           self.height = h
9
10      def __str__(self):
11          return  "({0}, {1}, {2})"
12                      .format(self.corner, self.width, self.height)
13
14  box = Rectangle(Point(0, 0), 100, 200)
15  bomb = Rectangle(Point(100, 80), 5, 10)    # In my video game
16  print("box: ", box)
17  print("bomb: ", bomb)
```

```
box: ((0, 0), 100, 200)
bomb: ((100, 80), 5, 10)
```

- To specify the upper-left corner embed a Point object within the new Rectangle object
- Create two new Rectangle objects, and then print them producing

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

DOT OPERATOR COMPOSITION



- The dot operator composes.
- The expression **box.corner.x** means:
  "Go to the object that box refers to and select its attribute named corner, then go to that object and select its attribute named x"

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OBJECTS ARE MUTABLE


```
1  class Rectangle:
2      # ...
3
4      def grow(self, delta_width, delta_height):
5          """ Grow (or shrink) this object by the deltas """
6          self.width += delta_width
7          self.height += delta_height
8
9      def move(self, dx, dy):
10         """ Move this object by the deltas
11         self.corner.x += dx
12         self.corner.y += dy
```

```
>>> r = Rectangle(Point(10,5), 100, 50)
>>> print(r)
((10, 5), 100, 50)
>>> r.grow(25, -10)
>>> print(r)
((10, 5), 125, 40)
>>> r.move(-10, 10)
print(r)
((0, 15), 125, 40)
```

- Change the state of an object by making an assignment to one of its attributes.

```
box.width += 50
box.height += 100
```

- Provide a method to encapsulate this inside the class.
- Provide another method to *move the position of the rectangle elsewhere*

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OBJECT EQUALITY

```
>>> p1 = Point(3, 4)
>>> p2 = Point(3, 4)
>>> p1 is p2
False
```

```
>>> p3 = p1
>>> p1 is p3
True
```

- EXAMPLE: if two *objects* are the same, does it mean they contain the same data or that they are the same object?
- The **is** operator was used in previous examples on the lists when explaining aliases: *it allows to find out if two references refer to the same object*

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OBJECT EQUALITY

```
1  def same_coordinates(p1, p2):
2      return (p1.x == p2.x) and (p1.y == p2.y)
```

```
>>> p1 = Point(3, 4)
>>> p2 = Point(3, 4)
>>> same_coordinates(p1, p2)
True
```

- **Shallow equality**: When **is** is True, this type of equality is called *shallow equality* because it compares only the *references* and not the *contents* of the objects
- **Deep equality**: To compare the contents of the objects a function like *same_coordinates* needs to be created

- NOTE: if two variables refer to the same object, they have both shallow and deep equality

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OBJECT EQUALITY

```
1  p = Point(4, 2)
2  s = Point(4, 2)
3  print("== on Points returns", p == s)
4  # By default, == on Point objects does a shallow equality test
5
6  a = [2,3]
7  b = [2,3]
8  print("== on lists returns",  a == b)
9  # But by default, == does a deep equality test on lists
```

```
== on Points returns False
== on lists returns True
```

- Think about shallow & deep copy when designing classes!
- EXAMPLE: even though the two lists (or tuples, etc.) are *distinct objects with different memory addresses*, for lists the == operator tests for *deep equality*, while in the case of points it makes a *shallow test*

source http://openbookproject.net/thinkcs/python/english3e/classes_and_objects_II.html

OBJECT COPY

```
>>> import copy
>>> p1 = Point(3, 4)
>>> p2 = copy.copy(p1)
>>> p1 is p2
False
>>> same_coordinates(p1, p2)
True
```

- Aliasing makes code difficult to read – *changes made in one place might have unexpected effects in another place*
- Copying object is an **alternative to aliasing:** the **copy module** contains a function copy that can duplicate any object
- EXAMPLE: import the copy module and use the copy function to make a new Point: p1 and p2 are *not the same point*, but they *contain the same data* (shallow copy)

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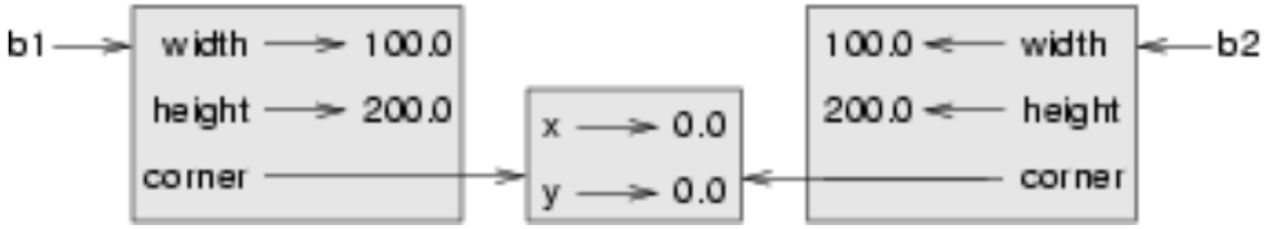
OBJECT COPY



- EXAMPLE: Assume Rectangle, which contains a reference to a Point: copy copies the reference to the Point object, so both the old Rectangle and the new one refer to a single Point.
- Invoking *grow* on one of the Rectangle objects would not affect the other,
  but invoking *move* on either would affect both
- The *shallow copy has created an alias to the Point that represents the corner*
- Copy module contains a function named **deepcopy** that copies not only the object but also any embedded objects

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- **Deep copy**: To copy the contents of an object as well as any embedded objects, and any objects embedded in them, etc. (*implemented as deepcopy function in copy module*)
- **Deep equality**: Equality of values, or two references that point to objects that have the same value.
- **Shallow copy**: To copy the contents of an object, including any references to embedded objects.
(*implemented by the copy function in the copy module*)
- **Shallow equality**: Equality of references, or two references that point to the same object.

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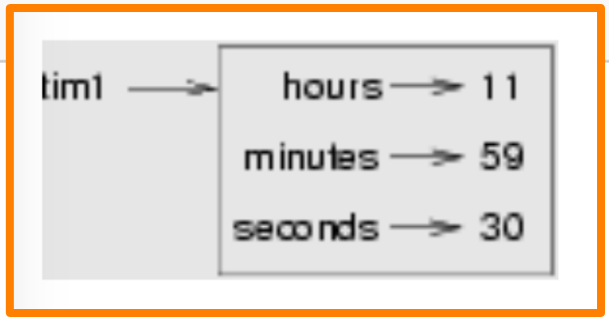
CLASSES, OBJECTS

```
1  class MyTime:
2
3      def __init__(self, hrs=0, mins=0, secs=0):
4          """ Create a MyTime object initialized to hrs, mins, secs """
5          self.hours = hrs
6          self.minutes = mins
7          self.seconds = secs
```

```
1  tim1 = MyTime(11, 59, 30)
```



- EXAMPLE: user-defined type called **MyTime** that records the time of day
- Initializer using an **__init__** method to ensure that every instance is created with appropriate attributes

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PURE FUNCTIONS

```
1  def add_time(t1, t2):
2      h = t1.hours + t2.hours
3      m = t1.minutes + t2.minutes
4      s = t1.seconds + t2.seconds
5      sum_t = MyTime(h, m, s)
6      return sum_t
```

```
>>> current_time = MyTime(9, 14, 30)
>>> bread_time = MyTime(3, 35, 0)
>>> done_time = add_time(current_time, bread_time)
>>> print(done_time)
12:49:30
```

- EXAMPLE: write two versions of a function **add_time**, which calculates the sum of two MyTime objects
- Function that creates a new MyTime object and returns a reference to the new object is **pure function** *because it does not modify any of the objects passed to it as parameters and it has no side effects*

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```
1   def add_time(t1, t2):
2
3       h = t1.hours + t2.hours
4       m = t1.minutes + t2.minutes
5       s = t1.seconds + t2.seconds
6
7       if s >= 60:
8           s -= 60
9           m += 1
10
11      if m >= 60:
12          m -= 60
13          h += 1
14
15      sum_t = MyTime(h, m, s)
16      return sum_t
```

EXAMPLE: create two **MyTime** objects: **current_time**, which contains the current time; and **bread_time**, which contains the amount of time it takes for a breadmaker to make bread. Then use **add_time** to figure out when the bread will be done

PROBLEM: we do not deal with cases where *the number of seconds or minutes adds up to more than sixty*.

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MODIFIERS

```
1  def increment(t, secs):
2      t.seconds += secs
3
4      if t.seconds >= 60:
5          t.seconds -= 60
6          t.minutes += 1
7
8      if t.minutes >= 60:
9          t.minutes -= 60
10         t.hours += 1
```

```
1  def increment(t, seconds):
2      t.seconds += seconds
3
4      while t.seconds >= 60:
5          t.seconds -= 60
6          t.minutes += 1
7
8      while t.minutes >= 60:
9          t.minutes -= 60
10         t.hours += 1
```

- It can be useful for a function to **modify** one or more of the objects it gets as parameters
- Usually, the **caller keeps a reference** to the objects it passes, so any changes the function makes are visible to the caller (*modifier function*)
- Increment, which adds a given number of seconds to a MyTime object, is a natural example of a **modifier**

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```python
class MyTime:
    # Previous method definitions here...

    def increment(self, seconds):
        self.seconds += seconds

        while self.seconds >= 60:
            self.seconds -= 60
            self.minutes += 1

        while self.minutes >= 60:
            self.minutes -= 60
            self.hours += 1
```

```python
current_time.increment(500)
```

- Include functions that work with MyTime objects into the MyTime class (conversion of *increment* to a method)
- Move the definition into the class definition and change the name of the first parameter to self (Python convention)

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INSIGHT

```
1  class MyTime:
2      # ...
3
4      def to_seconds(self):
5          """ Return the number of seconds represented
6              by this instance
7          """
8          return self.hours * 3600 + self.minutes * 60 + self.seconds
```

```
1  hrs = tsecs // 3600
2  leftoversecs = tsecs % 3600
3  mins = leftoversecs // 60
4  secs = leftoversecs % 60
```

- INSIGHT: MyTime object is a **three-digit number in base 60**!
- Another approach —convert the MyTime object into a *single number*
- The above method is added to the MyTime class to convert any instance into a corresponding number of seconds

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```
1   class MyTime:
2       # ...
3
4       def __init__(self, hrs=0, mins=0, secs=0):
5           """ Create a new MyTime object initialized to hrs, mins, secs.
6               The values of mins and secs may be outside the range 0-59,
7               but the resulting MyTime object will be normalized.
8           """
9
10          # Calculate total seconds to represent
11          totalsecs = hrs*3600 + mins*60 + secs
12          self.hours = totalsecs // 3600        # Split in h, m, s
13          leftoversecs = totalsecs % 3600
14          self.minutes = leftoversecs // 60
15          self.seconds = leftoversecs % 60
```

- In OOP **wrap together the data and the operations**
- Solution is to *rewrite the class initializer* so that it can cope with initial values of seconds or minutes that are outside the normalized values

(*normalized time: 3 hours 12 minutes and 20 seconds; the same time but not normalized 2 hours 70 minutes and 140 seconds*)

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EXAMPLE

```
>>> t1 = MyTime(10, 55, 12)
>>> t2 = MyTime(10, 48, 22)
>>> after(t1, t2)                # Is t1 after t2?
True
```

- EXAMPLE: The **after** function should compare two times and *specify whether the first time is strictly after the second*
- More complicated because it operates on **two MyTime objects** not just one

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EXAMPLE

```
1  class MyTime:
2      # Previous method definitions here...
3
4      def after(self, time2):
5          """ Return True if I am strictly greater than time2 """
6          if self.hours > time2.hours:
7              return True
8          if self.hours < time2.hours:
9              return False
10
11         if self.minutes > time2.minutes:
12             return True
13         if self.minutes < time2.minutes:
14             return False
15         if self.seconds > time2.seconds:
16             return True
17
18         return False
```

```
1  if current_time.after(done_time):
2      print("The bread will be done before it starts!")
```

- Lines 11-18 will only be reached if the two hour fields are the same.
- The test at line 16 is only executed if both times have the same hours and the same minutes.

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EXAMPLE

```
1  class MyTime:
2      # Previous method definitions here...
3
4      def after(self, time2):
5          """ Return True if I am strictly greater than time2 """
6          return self.to_seconds() > time2.to_seconds()
```

- The whole example can be made easier using the *previously discovered insight* of converting the time into single integer!
- This is a great way to code this:

  if we want to tell if the first time is after the second time, turn them both into integers and compare the integers.

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```
1  class MyTime:
2      # Previously defined methods here...
3
4      def __add__(self, other):
5          return MyTime(0, 0, self.to_seconds() + other.to_seconds())
```

- **Operator overloading**: possibility to have different meanings for the same operator when applied to different types
- EXAMPLE: the **+** in Python means quite different things for integers (**addition**) and for strings (**concatenation**)!
- To override the **addition operator +** provide a method named **__add__**

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OPERATOR OVERLOADING

```
1  class MyTime:
2      # Previously defined methods here...
3
4      def __add__(self, other):
5          return MyTime(0, 0, self.to_seconds() + other.to_seconds())
```

```
>>> t1 = MyTime(1, 15, 42)
>>> t2 = MyTime(3, 50, 30)
>>> t3 = t1 + t2
>>> print(t3)
05:06:12
```

- First parameter is the object on which the method is invoked
- Second parameter is named *other* to distinguish it from self
- To add two MyTime objects create and return a new MyTime object that contains their sum
- The expression t1 + t2 is equivalent to **t1.__add__(t2)**

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```
1  class Point:
2      # Previously defined methods here...
3
4      def __add__(self, other):
5          return Point(self.x + other.x,  self.y + other.y)
```

- EXAMPLE: back to the Point class – adding two points adds their respective (x, y) coordinates

- EXAMPLE: several ways to override the behavior of the *multiplication operator*: by defining a method named **__mul__**, or **__rmul__**, or both

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OPERATOR OVERLOADING

```
1  def __mul__(self, other):
2      return self.x * other.x + self.y * other.y
```

```
1  def __rmul__(self, other):
2      return Point(other * self.x,  other * self.y)
```

- If the left operand of * is a **Point**, Python invokes **__mul__**, which assumes that the *other operand is also a Point* (*this computes the dot product of the two Points*)
- If the left operand of * is a **primitive type** and the right operand is a **Point**, Python invokes **__rmul__**, which performs *scalar multiplication*
- The result is always a *new Point whose coordinates are a multiple of the original coordinates*

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```
>>> p1 = Point(3, 4)
>>> p2 = Point(5, 7)
>>> print(p1 * p2)
43
>>> print(2 * p2)
(10, 14)
```

```
>>> print(p2 * 2)
AttributeError: 'int' object has no attribute 'x'
```

- EXAMPLE: How is **p2 * 2** evaluated?

  Since the first parameter is a Point, Python invokes **__mul__** with 2 as the second argument. Inside **__mul__**, the program tries to access the **x** coordinate of other, which fails because an integer has no attributes

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POLYMORPHISM

```
1  def multadd (x, y, z):
2      return x * y + z
```

```
>>> multadd (3, 2, 1)
7
```

```
>>> p1 = Point(3, 4)
>>> p2 = Point(5, 7)
>>> print(multadd (2, p1, p2))
(11, 15)
>>> print(multadd (p1, p2, 1))
44
```

- **Polymorphism**: there are certain operations that can be applied *to many types*, such as the arithmetic operations

- EXAMPLE: **multadd** operation takes three parameters: multiplies the first two and then adds the third
- The first case: the Point is multiplied by a scalar and then added to another Point.
- The second case: the dot product yields a numeric value, so the third parameter also has to be a numeric value

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```
1  def front_and_back(front):
2      import copy
3      back = copy.copy(front)
4      back.reverse()
5      print(str(front) + str(back))
```

```
>>> my_list = [1, 2, 3, 4]
>>> front_and_back(my_list)
[1, 2, 3, 4][4, 3, 2, 1]
```

- EXAMPLE: **front_and_back** – consider a function which prints a list twice, forward and backward
- The reverse method is a **modifier** therefore a copy needs to be made before applying it (*this way we prevent to modify the list the function gets as a parameter*)
- Function like this that can take arguments with different types is called **polymorphic**

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```
1  def reverse(self):
2      (self.x , self.y) = (self.y, self.x)
```

```
>>> p = Point(3, 4)
>>> front_and_back(p)
(3, 4)(4, 3)
```

- Python's fundamental rule of polymorphism called the **duck typing rule**:

  If all of the operations inside the function can be applied to the type, the function can be applied to the type.

- The operations in the **front_and_back** function: *copy, reverse, print*
- SOLUTION: copy works on any object, already written a **__str__** method for Point objects, only reverse method for the Point class is needed

source http://openbookproject.net/thinkcs/python/english3e/even_more_oop.html

```python
import datetime  # we will use this for date objects


class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

    def age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month,
                                 self.birthdate.day):
            age -= 1

        return age


person = Person(
    "Jane",
    "Doe",
    datetime.date(1992, 3, 12),  # year, month, day
    "No. 12 Short Street, Greenville",
    "555 456 0987",
    "jane.doe@example.com"
)
```

```
In[3]: print(person.name)
Jane
In[4]: print(person.email)
jane.doe@example.com
In[5]: print(person.age())
25
```

Exercise 1

1. Explain what the following variables refer to, and their scope:
    1. `Person`
    2. `person`
    3. `surname`
    4. `self`
    5. `age` (the function name)
    6. `age` (the variable used inside the function)
    7. `self.email`
    8. `person.email`

Answer to exercise 1

1. 1. `Person` is a class defined in the global scope. It is a global variable.
   2. `person` is an instance of the `Person` class. It is also a global variable.
   3. `surname` is a parameter passed into the `__init__` method – it is a local variable in the scope if the `__init__` method.
   4. `self` is a parameter passed into each instance method of the class – it will be replaced by the instance object when the method is called on the object with the `.` operator. It is a new local variable inside the scope of each of the methods – it just always has the same value, and by convention it is always given the same name to reflect this.
   5. `age` is a method of the `Person` class. It is a local variable in the scope of the class.
   6. `age` (the variable used inside the function) is a local variable inside the scope of the `age` method.
   7. `self.email` isn't really a separate variable. It's an example of how we can refer to attributes and methods of an object using a variable which refers to the object, the `.` operator and the name of the attribute or method. We use the `self` variable to refer to an object inside one of the object's own methods – wherever the variable `self` is defined, we can use `self.email`, `self.age()`, etc..
   8. `person.email` is another example of the same thing. In the global scope, our person instance is referred to by the variable name `person`. Wherever `person` is defined, we can use `person.email`, `person.age()`, etc..

```python
import datetime  # we will use this for date objects


class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

    def age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month,
                                 self.birthdate.day):
            age -= 1

        return age

```

Exercise 2

1. Rewrite the `Person` class so that a person's age is calculated for the first time when a new person instance is created, and recalculated (when it is requested) if the day has changed since the last time that it was calculated.

Answer to exercise 2

1. Here is an example program:

```
import datetime

class Person:

    def __init__(self, name, surname, birthdate, address, telephone, email):
        self.name = name
        self.surname = surname
        self.birthdate = birthdate

        self.address = address
        self.telephone = telephone
        self.email = email

        # This isn't strictly necessary, but it clearly introduces these attributes
        self._age = None
        self._age_last_recalculated = None

        self._recalculate_age()

    def _recalculate_age(self):
        today = datetime.date.today()
        age = today.year - self.birthdate.year

        if today < datetime.date(today.year, self.birthdate.month, self.birthdate.day):
            age -= 1

        self._age = age
        self._age_last_recalculated = today

    def age(self):
        if (datetime.date.today() > self._age_last_recalculated):
            self._recalculate_age()

        return self._age
```

Exercise 3

1. Explain the differences between the attributes `name`, `surname` and `profession`, and what values they can have in different instances of this class:

```
class Smith:
    surname = "Smith"
    profession = "smith"

    def __init__(self, name, profession=None):
        self.name = name
        if profession is not None:
            self.profession = profession
```

```
class Smith:
    surname = "Smith"
    profession = "smith"

    def __init__(self, name, profession=None):
        self.name = name
        if profession is not None:
            self.profession = profession
```

Answer to exercise 3

1. `name` is always an instance attribute which is set in the constructor, and each class instance can have a different name value. `surname` is always a class attribute, and cannot be overridden in the constructor – every instance will have a surname value of `Smith`. `profession` is a class attribute, but it can optionally be overridden by an instance attribute in the constructor. Each instance will have a profession value of `smith` unless the optional `surname` parameter is passed into the constructor with a different value.

Exercise 4

1. Create a class called `Numbers`, which has a single class attribute called `MULTIPLIER`, and a constructor which takes the parameters `x` and `y` (these should all be numbers).
    1. Write a method called `add` which returns the sum of the attributes `x` and `y`.
    2. Write a class method called `multiply`, which takes a single number parameter `a` and returns the product of `a` and `MULTIPLIER`.
    3. Write a static method called `subtract`, which takes two number parameters, `b` and `c`, and returns `b - c`.
    4. Write a method called `value` which returns a tuple containing the values of `x` and `y`. Make this method into a property, and write a setter and a deleter for manipulating the values of `x` and `y`.

Answer to exercise 4

1. Here is an example program:

```
class Numbers:
    MULTIPLIER = 3.5

    def __init__(self, x, y):
        self.x = x
        self.y = y

    def add(self):
        return self.x + self.y

    @classmethod
    def multiply(cls, a):
        return cls.MULTIPLIER * a

    @staticmethod
    def subtract(b, c):
        return b - c

    @property
    def value(self):
        return (self.x, self.y)

    @value.setter
    def value(self, xy_tuple):
        self.x, self.y = xy_tuple

    @value.deleter
    def value(self):
        del self.x
        del self.y
```

Create a class called `Numbers`, which has a single class attribute called `MULTIPLIER`, and a constructor which takes the parameters `x` and `y` (these should all be numbers).

1. Write a method called `add` which returns the sum of the attributes `x` and `y`.
2. Write a class method called `multiply`, which takes a single number parameter `a` and returns the product of `a` and `MULTIPLIER`.
3. Write a static method called `subtract`, which takes two number parameters, `b` and `c`, and returns `b - c`.
4. Write a method called `value` which returns a tuple containing the values of `x` and `y`. Make this method into a property, and write a setter and a deleter for manipulating the values of `x` and `y`.

Exercise 5

1. Create an instance of the `Person` class from example 2. Use the `dir` function on the instance. Then use the `dir` function on the class.
    1. What happens if you call the `__str__` method on the instance? Verify that you get the same result if you call the `str` function with the instance as a parameter.
    2. What is the type of the instance?
    3. What is the type of the class?
    4. Write a function which prints out the names and values of all the custom attributes of any object that is passed in as a parameter.

INSPECTING OBJECTS

```
In[2]: class Person:
   ...:     def __init__(self, name, surname):
   ...:         self.name = name
   ...:         self.surname = surname
   ...:
   ...:     def fullname(self):
   ...:         return "%s %s" % (self.name, self.surname)
   ...:
   ...: jane = Person("Jane", "Smith")
   ...:
In[3]: print(dir(jane))
['__doc__', '__init__', '__module__', 'fullname', 'name', 'surname']

In[4]:
```

- Use function **dir** for inspecting objects: output list of the attributes and methods

Answer to exercise 5

1. 1. You should see something like `'<__main__.Person object at 0x7fcb233301d0>'`.
   2. `<class '__main__.Person'>` – `__main__` is Python's name for the program you are executing.
   3. `<class 'type'>` – any class has the type `type`.
   4. Here is an example program:

```
def print_object_attrs(any_object):
    for k, v in any_object.__dict__.items():
        print("%s: %s" % (k, v))
```

Exercise 6

1. Write a class for creating completely generic objects: its `__init__` function should accept any number of keyword parameters, and set them on the object as attributes with the keys as names. Write a `__str__` method for the class – the string it returns should include the name of the class and the values of all the object's custom instance attributes.

Answer to exercise 6

1. Here is an example program:

```
class AnyClass:
    def __init__(self, **kwargs):
        for k, v in kwargs.items():
            setattr(self, k, v)

    def __str__(self):
        attrs = ["%s=%s" % (k, v) for (k, v) in self.__dict__.items()]
        classname = self.__class__.__name__
        return "%s: %s" % (classname, " ".join(attrs))
```

REFERENCES

This lecture re-uses selected parts of the OPEN BOOK PROJECT

Learning with Python 3 (RLE)

http://openbookproject.net/thinkcs/python/english3e/index.html

available under GNU Free Documentation License Version 1.3)

- Version date: October 2012
- by Peter Wentworth, Jeffrey Elkner, Allen B. Downey, and Chris Meyers (based on 2nd edition by Jeffrey Elkner, Allen B. Downey, and Chris Meyers)
- Source repository is at https://code.launchpad.net/~thinkcspy-rle-team/thinkcspy/thinkcspy3-rle
- For offline use, download a zip file of the html or a pdf version from http://www.ict.ru.ac.za/Resources/cspw/thinkcspy3/

This lecture re-uses selected parts of the PYTHON TEXTBOOK

Object-Oriented Programming in Python

http://python-textbok.readthedocs.io/en/1.0/Classes.html#

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